



# **L5 Signal Characteristics**

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# Topics

- **L5 Signal Design Status**
- **Characteristics Summary**
- **PN Code Structure and Properties**
- **Signal Modulation**
- **Data Structure**
- **Data Content**

# **L5 Signal Design Status**

- **Signal design is complete**
- **RTCA SC159 is publishing an L5 Signal Specification**
  - **Version 1 will be mailed to committee members this week for review**
  - **Some specification details affected by SV design are replaced with comments**
    - **Phase Noise specification**
    - **Correlation Loss specification**
    - **Detailed Received Power specification**

# **Specification Details Affected by SV Design**

- **Changes are also being proposed for SPS Specification**
- **Prefer that signal characteristics be given rather than general effects**
  - **Bandwidth, antenna pattern, EIRP, phase noise spectral density**
  - **Let diversified users evaluate based upon application**

# Characteristics Summary

- **L5 = 1176.45 MHz**
- **Allocated BW = 24 MHz (anticipated)**
- **Minimum Received Power = -154 dBW**
- **PN Code Chipping Rate = 10.23 MHz**
- **QPSK Signal**
  - **In-Phase (I) = Data Channel**
  - **Quadrature (Q) = Data-Free Channel**
  - **Equal Power in I and Q (-157 dBW)**
  - **Independent PN Codes on I and Q**

# Characteristics Summary (Cont.)

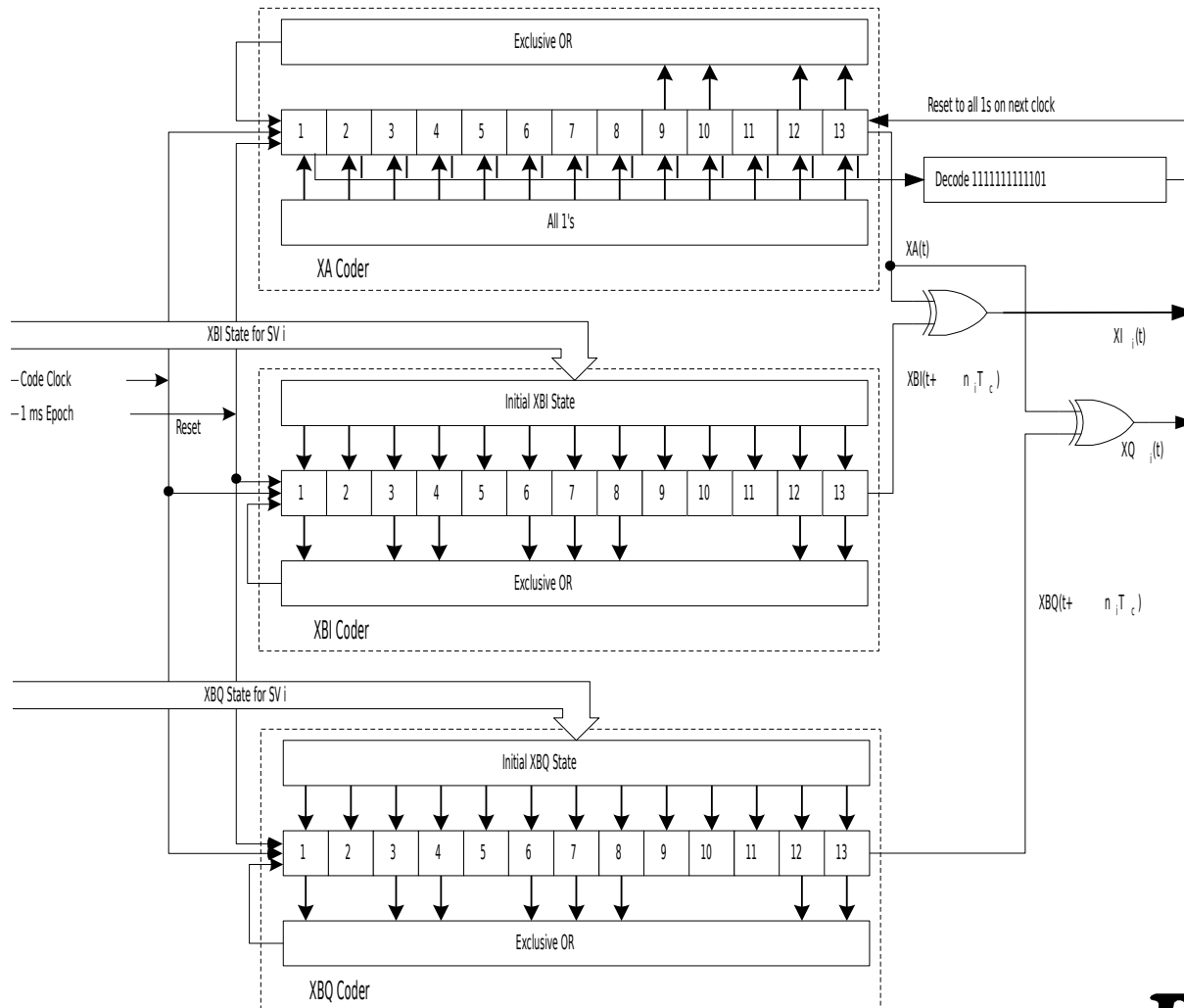
- **I and Q Modulation (1 kbps)**
  - **FEC encoded 50 bps data on I (100 sps)**
    - **Further encoded with 10-bit Neuman-Hoffman Code**
  - **Q encoded with 20-bit Neuman-Hoffman Code**
  - **More details to follow**

# **L5 Codes and Code Properties**

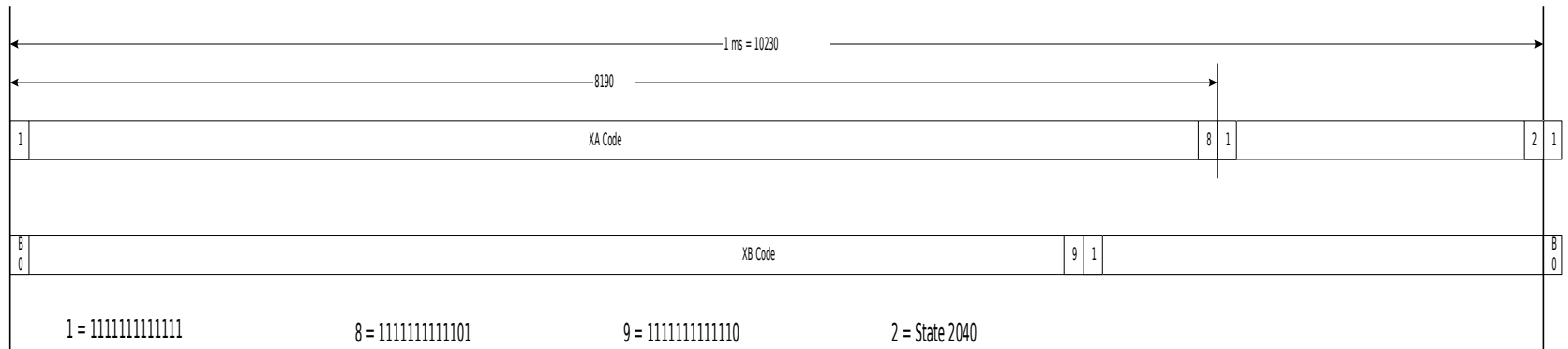
# L5 Codes

- **Codes with 2 - 13 stage shift registers**
  - Length of one (XA code) = 8190 chips
  - Length of second (XB code) = 8191 chips
  - Exclusive-Or'd together to generate longer code
- **Chipping rate of 10.23 MHz**
  - Reset with 1 ms epochs (10,230 chips)
- **Two codes per satellite (4096 available)**
  - One for Data channel, one for Data-Free channel

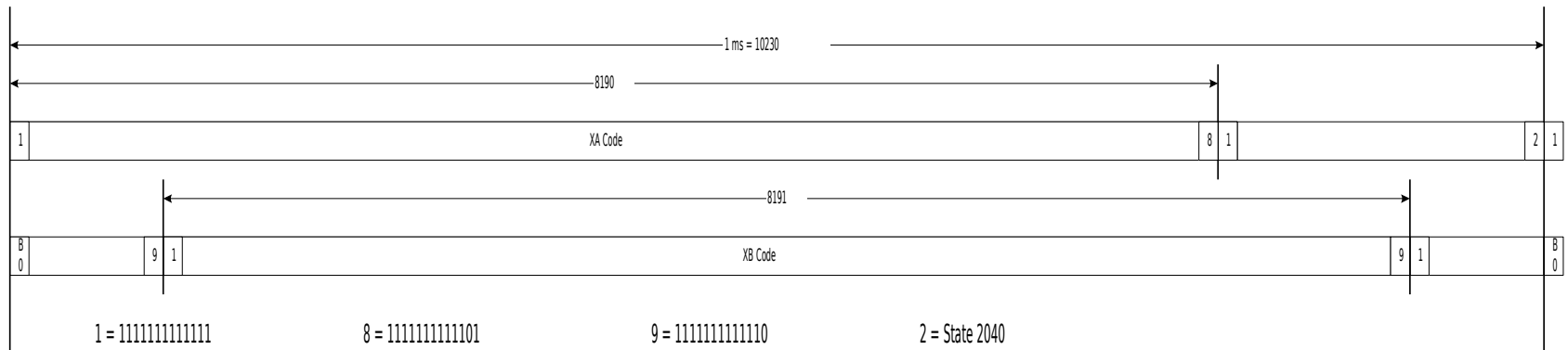
# L5 I & Q Code Generators



# L5 Code Generator Timing



a) B0 = Initial State at 1 ms (less than State 6152)



b) B0 = Initial State at 1 ms (greater than State 6151)

# L5 Code Performance Summary

- **74 Codes have been selected**
  - 37 I, Q pairs
- **Maximum non-peak autocorrelation  $\approx$  -30 dB**
- **Maximum cross-correlation with other selected codes  $\approx$  -27 dB**
- **Average autocorrelation and cross-correlation  $\approx$  -42 dB**
- **Maximum cross-correlation between I, Q pairs  $<$  -74.2 dB**
- **Another pair selected as non-standard code**

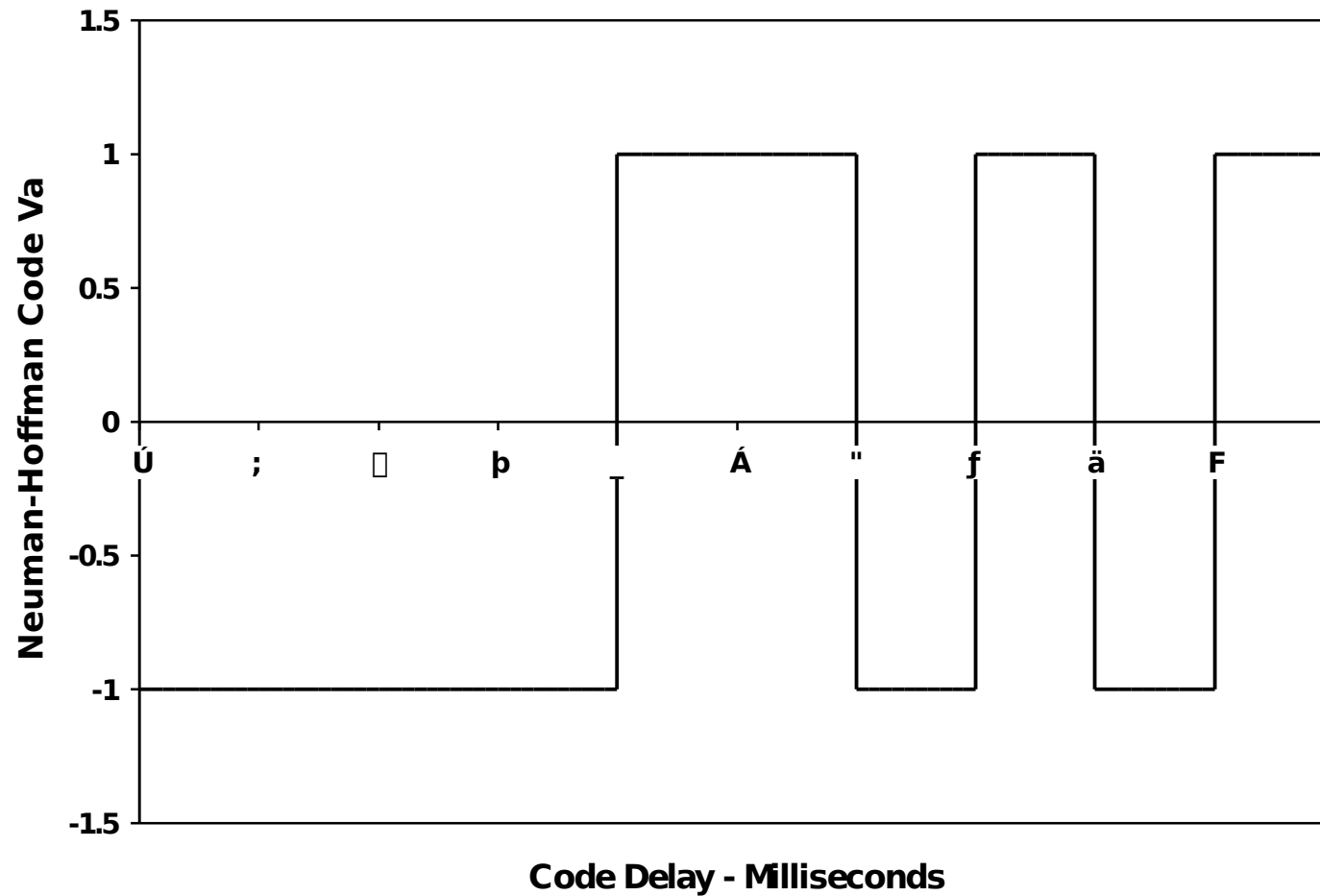
# L5 Signal Modulation



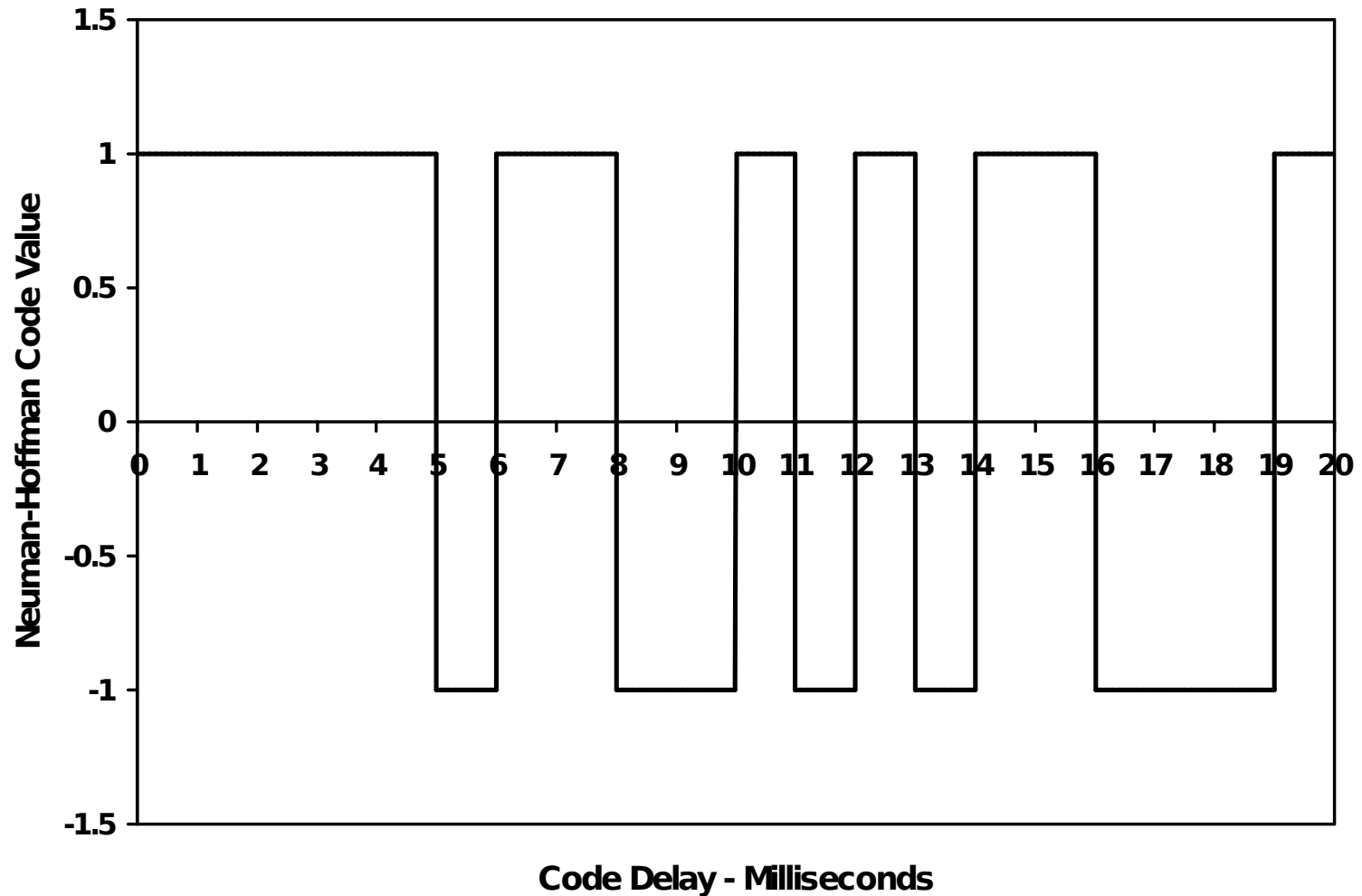
# Neuman-Hoffman Codes

- **Encoded symbols and carrier**
  - **Modulated at PN Code epoch rate**
  - **Spreads PN Code 1 kHz spectral lines to 50 Hz spectral lines (including FEC)**
    - **Reduces effect of narrowband interference by 13 dB**
      - **Primary purpose of NH Codes**
      - **Also allows detection of narrowband interference**
  - **Reduces SV cross-correlation most of the time**
  - **Provides more robust symbol/bit synchronization**

# 10-ms Neuman-Hoffman Code on I



# 20-ms Neuman-Hoffman Code on Q



# **L5 Data Content & Format**

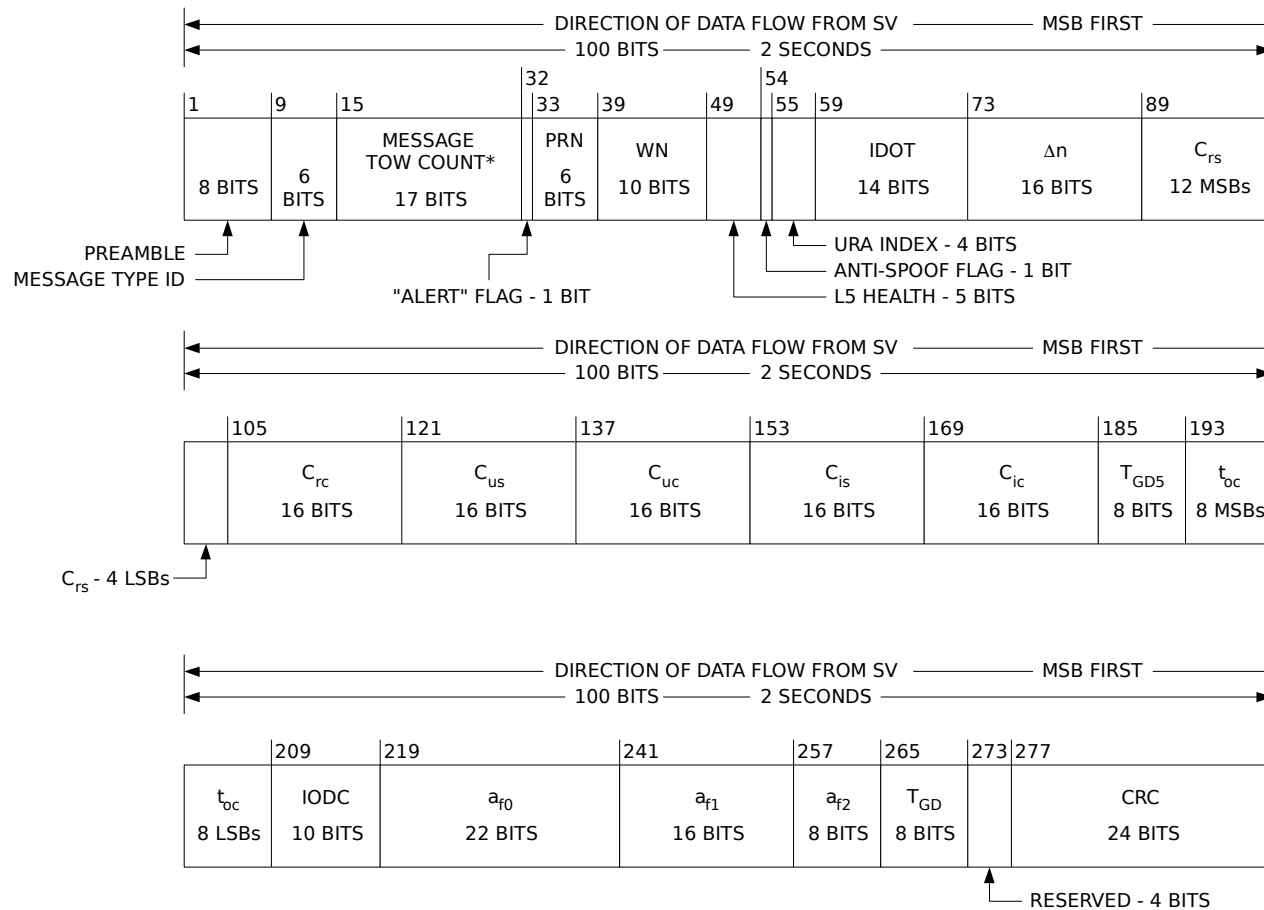
## **L5 Data Content & Format**

- **5 - Six-Second 300-bit Messages**
  - **Formatted with 24-bit CRC (same as WAAS)**
  - **Encoded with Rate 1/2 FEC**
    - **To make up for 3-dB QPSK reduction**
  - **Symbols modulated with 10-bit Neuman-Hoffman Code**
- **Messages scheduled for optimum receiver performance**
- **Lined up with L1 sub-frame epochs**

## **L5 Message Types (of 64 possible)**

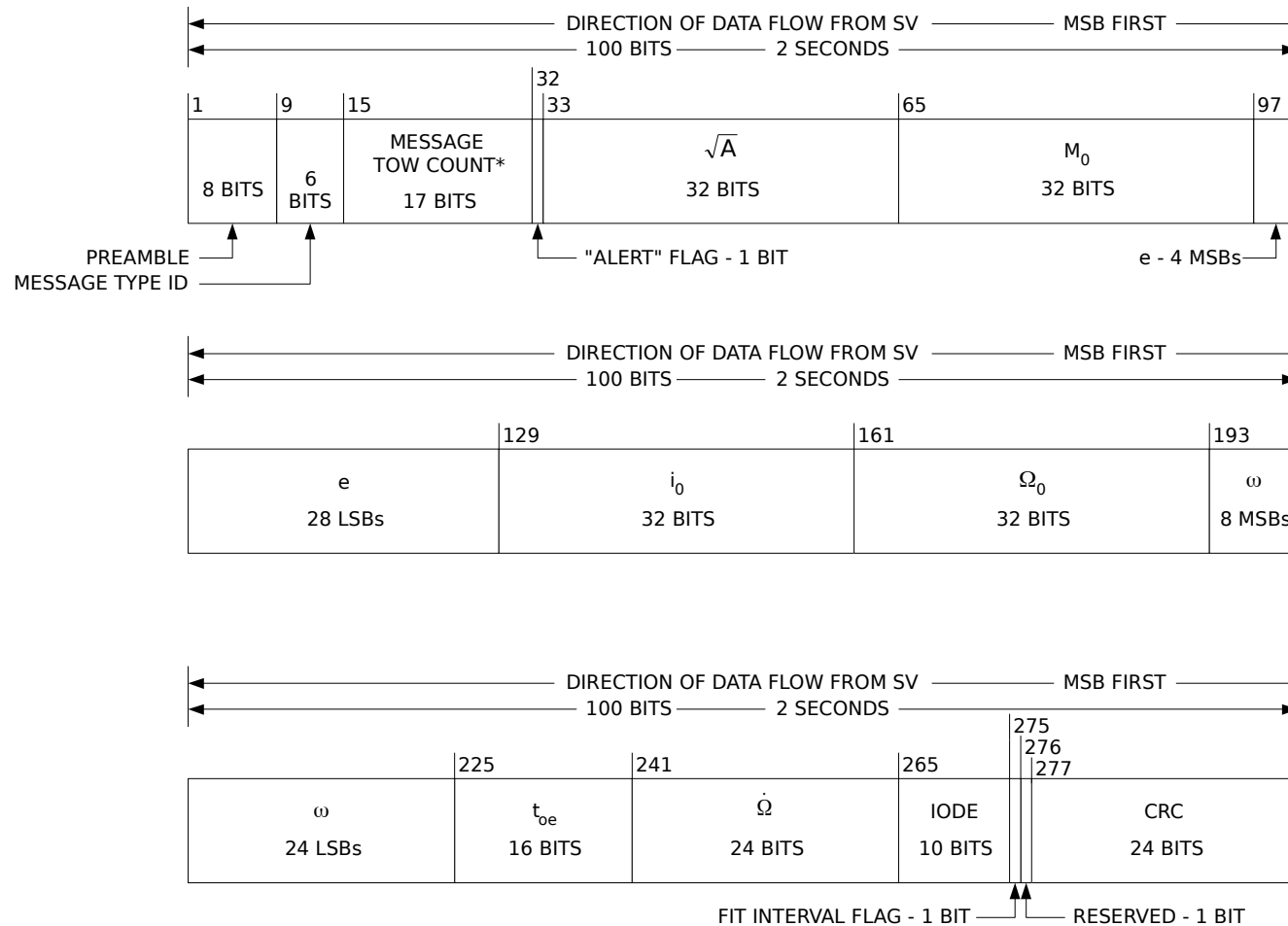
- **Message Type 1 - Ephemeris/Clock I**
- **Message Type 2 - Ephemeris/Clock II**
- **Message Type 3 - Ionosphere/UTC**
- **Message Type 4 - Almanac**
- **Message Type 5 - Text Message**
- **Anticipated that Ephemeris/Clock Messages would be repeated every 18-24 seconds**

# Message Type 1



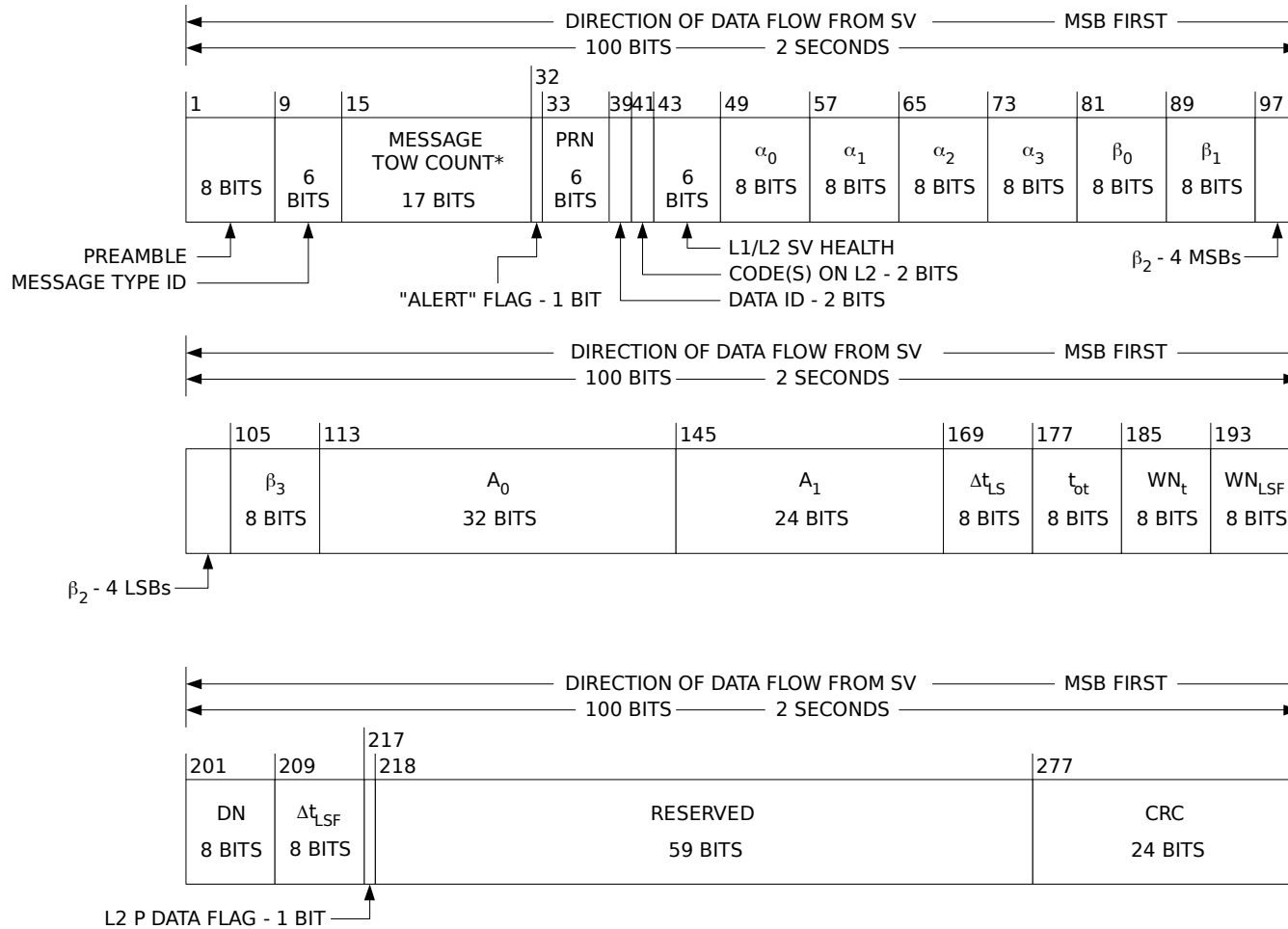
\* MESSAGE TOW COUNT = 17 MSBs OF ACTUAL TOW COUNT AT START OF NEXT 6-SECOND MESSAGE

# Message Type 2



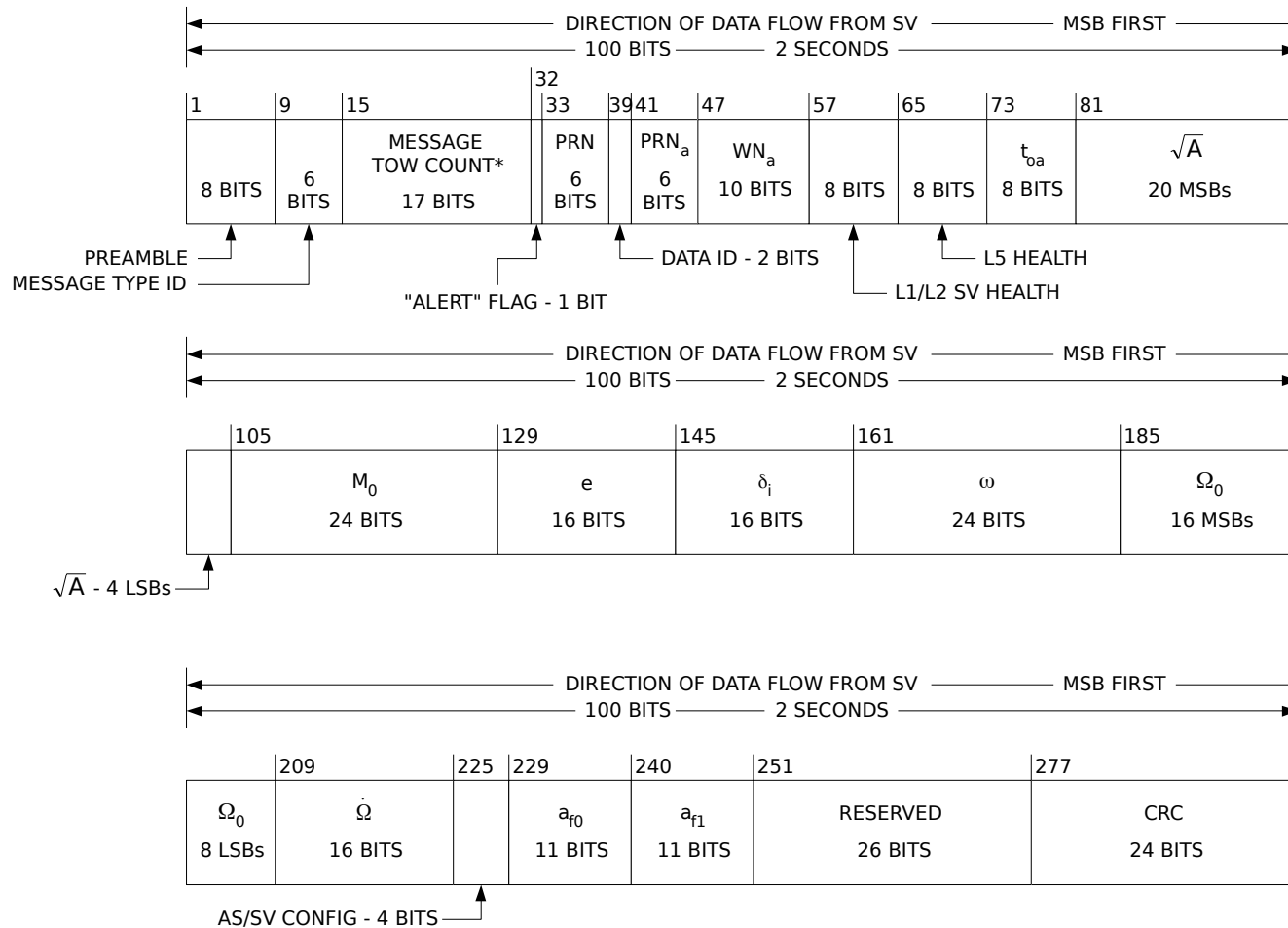
\* MESSAGE TOW COUNT = 17 MSBs OF ACTUAL TOW COUNT AT START OF NEXT 6-SECOND MESSAGE

# Message Type 3



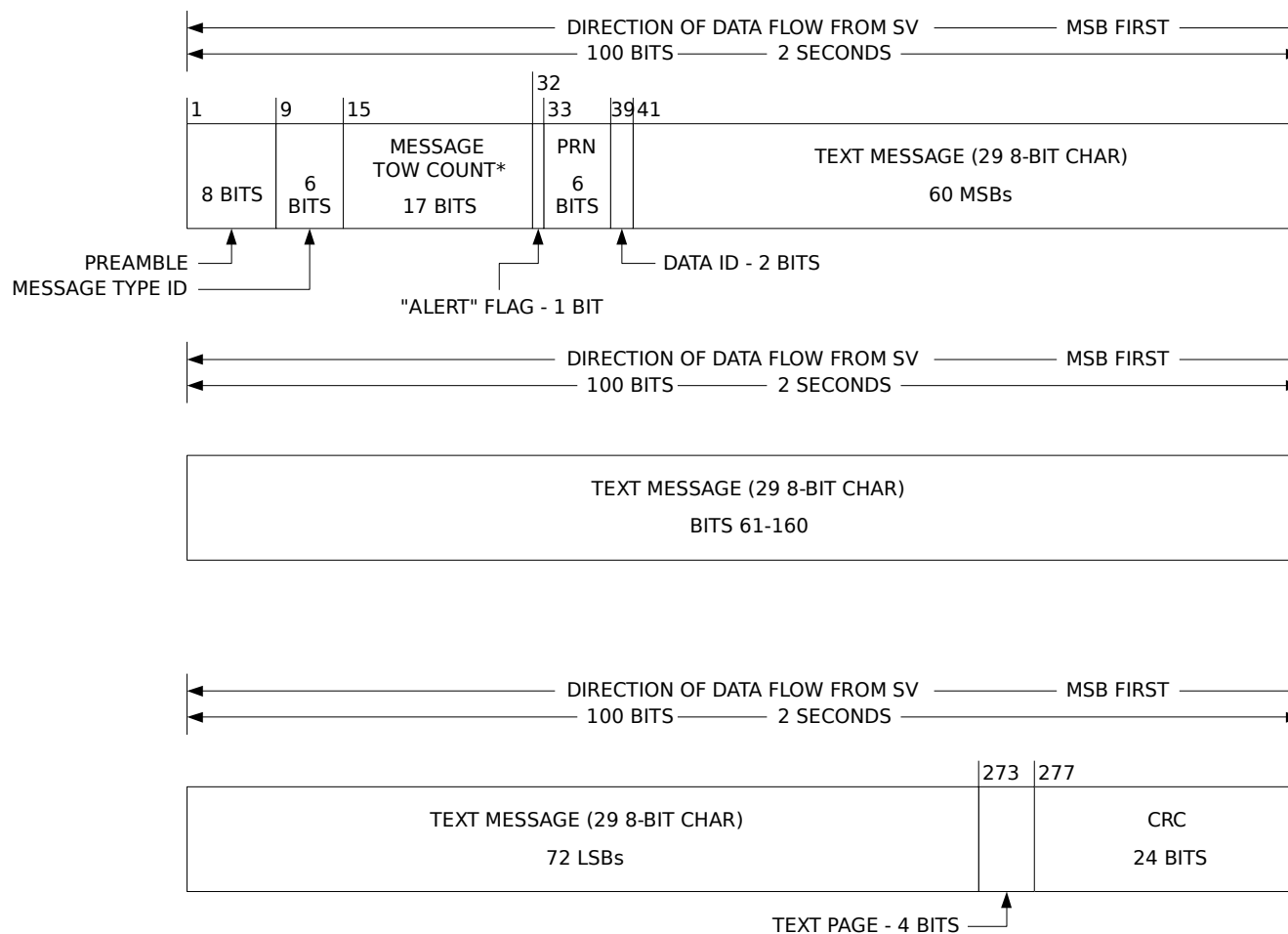
\* MESSAGE TOW COUNT = 17 MSBs OF ACTUAL TOW COUNT AT START OF NEXT 6-SECOND MESSAGE

# Message Type 4



\* MESSAGE TOW COUNT = 17 MSBs OF ACTUAL TOW COUNT AT START OF NEXT 6-SECOND MESSAGE

# Message Type 5



\* MESSAGE TOW COUNT = 17 MSBs OF ACTUAL TOW COUNT AT START OF NEXT 6-SECOND MESSAGE

# Message Content

- **Mostly, content is same as on L1**
- **Add L5 Group Delay variable**
- **Add L5 Health**
- **Different Text Message**
- **Add PRN number**
- **Peculiar L5 information can be provided by civil community**

# GPS III Considerations

- **Higher data rate to include integrity data for safety-of-life service**
  - Promised by Galileo
- **Second real-time uplink for and operated by safety-of-life service**
  - To meet integrity and time-to-alarm requirements

# Special Acknowledgements

- **Swen Ericson, MITRE**
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